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FACTORS INFLUENCING UTILIZATION OF AIR CARGO CONTAINERIZATION IN THE UNITED STATES AIR FORCE

THESIS

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THESIS

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Abstract

As the Department of Defense budget continues to decrease, the growing requirement to meet national strategic mobility objectives with limited resources provides a major impetus for cost-effective and credible transportation innovations. The commercial transportation industry has increasingly accepted cargo containerization as a method to take advantage of intermodal shipping efficiency and cost savings. The military implementation of these same shipping initiatives must be flexible, reliable, and compatible with the existing cargo handling systems already designed to deliver fighting forces to conflicts throughout the world.

This thesis examines cost and container utilization factors among units familiar with the ISU bins provided by AAR Cadillac Manufacturing. The objective is to evaluate the costs and factors experienced by the responsible units in the procurement, maintenance, and operation of these air cargo containerization systems. The research results indicate that the Life-cycle cost of containerization may be greater than the comparable costs of the current 463L palletization system. However, these units indicated several potential advantages to air cargo containerization implementation including: reduced contents damage, pilferage, and pre-clearance requirements; improved system reliability and cargo tracking capability; and better system operations.

FACTORS INFLUENCING UTILIZATION OF AIR CARGO CONTAINERIZATION IN THE UNITED STATES AIR FORCE

I. INTRODUCTION

Statement of the Problem

Air cargo containerization can reduce movement preparation times and pilferage and damage rates, while improving the in-transit visibility of each shipment. Widespread adoption of this technology in the United States Air Force (USAF), however, is hampered by perceived cost and system bottleneck issues (i.e. backhaul and storage). This research attempts to capture costs associated with procuring and maintaining air cargo containers provided by AAR Cadillac Manufacturing in Michigan and identify other non-cost factors to determine whether these systems should be used by the USAF.

Background

Air cargo containerization in the military can be described as a subset of a growing trend towards intermodalism in the transportation industry (Mancy, 1996:8). Decreasing the number of handling points, reducing the risk of loss and damage, and the efficiency associated with maximizing mode-specific transportation advantages recommend the adoption of containers to move unit cargo. The ease of handling, the integrity of newer containers made with stronger, more damage-resistant plastics, and the compatibility with existing military materials handling systems may provide distinct advantages for air containers when compared to the current pallet-based system.

The argument over the efficient use of cargo containerization technology, however, is not new to the United States military. An academic debate in the early 1970s extolled the purported advantages of containers over pallets to little avail. Ivan Gift, Gerald Sveen, and Tom Bing published separate thesis research efforts discussing the effect of cargo containerization for air transportation applications. Concerns over weight and storage of mass quantities of the containers, poor available information technology systems, and the inefficiency associated with return movements limited the application of containers throughout the military transportation system. Although the commercial transportation industry has recognized the advantages of containerization in surface, water, and even limited air, shipment applications, the military has largely ignored containerization use by private industry over the last 25 years.

Renewed emphasis on military down-sizing and rapid strategic mobility justify renewed interest of, and study on, the effects of air cargo containerization for the United States Air Force. The potential logistics and transportation efficiencies provided by adopting air cargo containerization could address critical resource allocation issues. The widespread unit conversion to air cargo containers from the present 463L pallet system could improve mobility responses, cargo accountability, and unit ownership of deployed assets, while possibly decreasing the costs associated with these cargo movements.

Scope

This research studies the feasibility of containerizing military air cargo shipments. Containerization in the commercial sector is an intermodal efficiency issue, designed to maximize inherent mode-specific advantages to reduce the total system cost of a cargo

movement. The United States Air Force relies on the decades-old pallet technology of the 463L system to standardize shipments among its various cargo-carrying airframes and with the equipment requirements of its Army, Navy, and Marine Corps customers.

This research focuses on identifying factors essential for the adoption of air cargo containerization systems in the United States Air Force. Limitations, advantages, and trade-offs inherent with container use will be discussed with current users of the technology. Costs will be broadly categorized (maintenance and repair, life expectancy, and procurement) to match comparable 463L pallet system costs incurred with the adoption of air cargo containers manufactured by AAR Cadillac Manufacturing. Costs associated with storage and the backhaul of containers will be discussed as factors in adoption of the technology, but not specifically quantified.

Containerization must be a unit and a system issue for the United States Air Force. The ability of all deployable units to afford the containers, store them, or take advantage of the transportation efficiencies offered by the technology remains untested. The Air Force deployment system remains reluctant to purchase large quantities of containers, store the devices, or recommend wholesale replacement of current 463L pallet technology in favor of strict containerization (Parsons, 1997). Although broad, the unit and system perspective is important if potential advantages, costs savings, or detriments of the adoption of air cargo containers are to be identified.

AAR Cadillac Manufacturing is positioning itself as the sole provider of efficient, effective air cargo containerization for the military. Mobilization Systems, an Ohio-based military contractor, was a previous provider for similar container equipment. Their units, however, were unable to meet shipper requirements for weight, cost, and reliability

standards (Baird, 1998). Presently, units may purchase individual container components from AAR Cadillac Manufacturing. The company then assumes the responsibility for dispatching maintenance teams as required to accomplish on-site preventive maintenance or repair services (Langstraat, 1998).

Advantages and factors concerning the 30-year use of the current 463L pallet system will not be discussed. Its mere steadfastness in the face of changing world economic and military climates indicates its acceptability as an important strategic air mobility tool. However, differences in deployment process requirements using pallets versus containerization methods will be compared to discover and qualify relative benefits or remaining challenges.

Research Approach

Factors relevant to container technology adoption have been discussed extensively in recent academic literature. Capturing these factors and applying them to the air transportation efforts of the United States Air Force will be the first step in this study. Sources will include published research, interviews with units using the containers, Cadillac AAR Manufacturing, and the Air Expeditionary Forces (AEF) battlelab at Mountain Home AFB ID.

Costs associated with the procurement, maintenance, and life expectancy of the containers will be collected from vendor provided data sources and information from the responsible staff and owning organizations within the United States Air Force. These costs will be matched to corresponding figures associated with using the current 463L pallet system. These costs will be compared for a one-year timeframe.

Capture of beneficial container utilization factors and the discovery of accurate, reliable cost figures for both the current pallet system and certain air cargo containers will provide the basis for conclusions for the current study. The costs associated with container adoption will be key, however, qualitative factors can help illustrate the total effect of system adoption. These factors will be collected from phone interviews conducted among responsible individuals and units already familiar with the container technology. Although the units and responsible individuals may possess common knowledge about the containers and their use, familiarity with particular systems does not constitute the endorsement of a particular product.

Results

This research illustrates the potential effect to Air Force strategic and unit mobility processes of adoption of air cargo containerization systems. The study provides important mobility information for the more rapid, more complex deployment environment of today's military. The conclusions provide insight into additional transportation and logistics efficiency issues concerned with adoption of these air cargo containerization systems.

Additionally, the research could minimally be expected to reopen the debate on air cargo containerization and serve merely as a position paper for potential container adoption. This result will necessitate more detailed cost and factor research to either recommend or dismiss the system adoption of containerization. Application of the research in this manner will simply extend the current use of the 463L pallet system, and relegate procurement of containers to strict unit initiatives.

II. LITERATURE REVIEW

Introduction

The choice by shippers to use cargo containerization for shipment remains a relatively new transportation innovation. Before applying various choice factors to Air Force use of containerization and discussing the costs of system implementation, the history, container characteristics, previous research, commercial applications, and regulatory guidance concerning cargo containerization will be examined. The development of a contemporary framework for these issues will conclude the discussion.

History

The use of cargo containers to ship material developed in several distinct phases spanning both military and commercial advances during the twentieth century. World War II combat operations forced the movement of personnel and their equipment to global theaters of war. Early military applications of containerization innovations were employed during the Korean War. Commercial container initiatives can be traced to post-Korean War intermodal efforts in water transportation. The Air Force developed a new material handling system for all of its cargo aircraft in 1963 to standardize equipment movements between the services. Despite the succession of technological and practical advances during the previous quarter of a century, the state of container art stagnated during the 1970s and into the present twenty-first century operational climate.

World War II (WWII) combat operations challenged the national military community. Resources were inadequate, training was rushed, and material production

lagged far behind that of nations more intimately familiar with the scourges of war. Early United States Army efforts to organize shipments of equipment to combat theaters were characterized by excessive time, money, and personnel challenges. Each of these vital resources was inordinately consumed to accomplish the cargo handling requirements of a newly combatant military (Bing, 1971:2). Following the end of the war, new methods to provide more efficient transportation were required as the military diminished in size.

The Korean War in June of 1950 provided the first opportunity to employ the new shipment methods designed to alleviate the shipment shortcomings of World War II. The Container Express (CONEX) program consisted of small, corrugated steel containers designed to unitize small batches of parts, supplies, or ammunition. This intermodal shipment method, used primarily for transport aboard ships or on flatbed trucks, was designed to function without the costly resource delays of transfer between the selected transportation modes. Additional innovations during this time included wooden vans for military and civilian household goods shipments across the Atlantic (Sveen, 1972:3).

Commercial industry joined the military in recognizing the importance of intermodal transportation and containerization efficiency. Malcolm McLean, a trucking company owner, recognized that "total distribution costs decreased only by streamlining the entire distribution process." On 20 April 1956, the converted Pan Atlantic steamship tanker, SS Mouton, moved from New York to Houston with 58 twenty-foot containers lashed on the deck. By 1957, 10 containerships were operating on routes controlled by McLean's shipping company, the newly named SeaLand Service (Transportation Research Board, 1992:17; Mahoney, 1985:13).

Although contemporaries, the fates of McLean's commercial shipping application and the CONEX program markedly diverged. The CONEX program failed to resolve critical transfer issues at forward operating locations. The lack of sufficient or adequate cargo handling equipment combined with the cumbersome physical characteristics of the "big, heavy box" meant that loading, unloading, or movement operations were impractical at locations outside of established port terminals. On the commercial side, McLean's early success in containerization efforts established a lasting change in material management and distribution practices (Bing, 1971: 34-5).

By the 1960s, the Air Force recognized that early inter-service attempts to facilitate cargo movement failed to produce lasting, consistent results. The 463L Material Handling System was designed to "improve the nation's capability to deploy and support overseas military operations by streamlining movement of unitized cargo through intransit points with a minimum of breakbulk handling" (Gift, 1971:25). Implemented in 1963, the 463L system simplified loading and unloading operations for all USAF cargo aircraft by "using a standard type of transporter load and incorporating the use of a singular pallet type as the base cargo carrying unit" (Carson and Munson, 1980:2).

The 463L system has remained the transportation standard for moving cargo throughout the Defense Transportation System (DTS), although several limits on its effectiveness have been identified since its implementation in the 1960s. Designed to be moved by water, land, and air modes of transportation, these pallets often suffered from exposure and damage. Further, the use of these pallets was limited due to incompatible material handling equipment available to facilitate intermodal operations. The pallets

were particularly susceptible to weather elements. Pallets offered little protection for cargo from climate conditions like rain or heat. The absence of pilferage prevention safeguards and the lack of weather protection highlighted the vulnerability of cargo shipped by pallet (Gift, 1971: 29-30). Aerial Port of Debarkation (APOD) operations frequently served as the terminus for pallets because they were incompatible with the transportation means available for forward movement of cargo. Some shipments were unable to be airlifted by helicopter because of the structural limits of the pallets. Other shipments were stranded on pallets with no integrated forklift tubes or trucks unable to accommodate the pallet dimensions (Carson and Munson, 1980:23-4). Additionally, pallets were frequently diverted to fulfill unauthorized functions. Tent floors, storage racks, huts, and walkways were often constructed of pallets, resulting in severe shortages of the assets throughout the DTS (Schroeder and Martinez, 1997: 2-3).

The system shortcomings of the 463L pallet encouraged examination of containers as a suitable alternative for moving military cargo. This initiative borrowed heavily from commercial applications already employing container techniques. In the 1970s, development of suitable air cargo containers for use in the military encompassed numerous design and performance specifications. These characteristics included:

- Decompression blowout panels
- Smooth exteriors
- Integrated interior restraint
- Side restraint lips
- Smooth bottoms for use on existing aircraft roller systems (Gift, 1971:14-5).

Major Ivan Gift concluded that the main advantage containers provided to the strategic airlift of equipment and material was the reduced cost of cargo handling operations (Gift, 16). The military application of this container technology meant that shippers were to have maximum access to the contents of each shipment (Berger and others, 1970: 4-29). The adequacy of these specifications will be examined in the Previous Research section.

Military examination of cargo containerization to address shipment efficiency and equipment protection concerns developed during distinct phases. From WWII to the present, efforts to address each system's shortcoming meant adoption of new systems to avoid previous challenges. Although the 463L system has remained in use for over thirty years, the recent advances in container technology and the limitations of the pallet system have renewed research efforts into air cargo containerization.

Container Characteristics

The research conducted for this thesis focused on air cargo container technology provided by Cadillac AAR Manufacturing. The specifications and widespread applicability of these units distinguish them from earlier containerization efforts.

The containers are a generation removed from the common corrugated metal 8x8x20-foot steel boxes. These containers are plastic, aluminum, or fiberglass and are sized to match the military standard 463L rail and lock system. The base dimension for most units is 88"x108". The containers vary from 60" high to the maximum 96" height accepted on Lockheed C-5 Galaxy aircraft. Contours exist to conform to fuselage requirements on both the Boeing KC-135 Stratotanker and McDonnell-Douglas KC-10 Extender. All containers include access doors, are available with function-specific

accessories, and can be shipped by intermodal transportation. Some containers include external lift capability for slinging underneath helicopters (Mobility Systems, 1997a).

Previous Research

The adoption of any container system for the United States Air Force should follow established research recommendations. Considerations must include infrastructure capacity, resource constraints, and potential opportunities and costs.

Airfield and port terminal facilities are critical components for the efficient movement of cargo through the Defense Transportation System. The Congressional Budget Office notes that airfield capacities are described by Maximum on Ground (MOG) standards. MOG figures are the "average number of planes that a particular airfield can service at any given time." Use of this standard indicates that the potential for aircraft handling is not constant over time and depends on the specific characteristics of each affected airfield. These factors include:

- The physical limitations of the airfield (ramp space)
- Refueling capabilities
- Availability of equipment to load and unload aircraft

The handling of containers moving military cargo through these terminals depends on the number of arriving and departing missions, and the amount of containers shipped by each airframe (Congressional Budget Office, 1997:12).

The availability and suitability of port facilities designed to handle both containerized and palletized equipment constitute additional infrastructure concerns. Storage of these containers represents a major challenge for existing port facilities. For

example, 52 ISU-90 containers (constructed by AAR Cadillac Manufacturing) would occupy 20,800 cubic feet of warehouse space. To store 52 existing 463L pallets, the space requirement would be only 400 cubic feet. The space savings associated with the storage of pallets are over 95% of the total requirement for the containers (Mancy, 1996:32).

Resource considerations limited the development of containerized movement systems in the military. The relative lack of military cargo containerization applications between the early 1970s, when current commercial practices of the technology gained acceptance, to the present can be attributed to the diminishing Department of Defense (DoD) resources available during the time period (Mancy, 1996:16). The rising cost of aviation fuel in the 1970s, coupled with the high tare weight and inflexible container configuration of the available corrugated steel containers, impeded a fledgling commercial trend to use the 8x8x20-foot containers for intermodal air-surface shipments (Mahoney, 1985:4,50-1). Major transportation innovations for the military during the same time included additional 40k loaders, the development of the 60k loader, the purchase of the McDonnell Douglas C-17 Globemaster III, and renovation of port facilities world-wide. The expense associated with these programs contributed to the absence of widespread air cargo containerization adoption in the military.

Air cargo containerization, despite resource constraints, possessed certain advantages for cargo movement that recommended military adoption of an intermodal-type system. In a survey conducted by Johnston and Marshall, shipping executives were asked to rate their perceptions of containers versus RoadRailer, Trailer on Flatcar (TOFC), or other familiar intermodal devices. Containers received high favorable ratings

for ease of loading and unloading, merchandise protection, and cleanliness, scoring better than any of their intermodal equipment competition. Ratings assigned to flexibility, cubic capacity, and gross weight capacity revealed that the other modes of intermodal equipment scored higher than containers (Johnston and Marshall, 1993:24).

Mancy developed additional research indicating the advantages of containerized shipments. These factors include:

- Reduced cargo damage (including vandalism and weather exposure)
- Reduced pilferage (containers can be locked and contents of particular shipments are hidden from view)
- Reduced handling (shipments can be sorted and marked prior to arrival at port facilities for embarkation or debarkation)
- Space efficiency aboard specific aircraft
- Cargo tracking (important with newly developed intransit visibility initiatives)
- Truck/Rail transshipment compatibility (ability to seamlessly move through APOE/APOD facilities) (Mancy, 1996:19-24).

These advantages are mirrored in additional research of intermodal applications for cargo containers. Improper packaging and cargo storage within the containers account for nearly 90% of the losses assigned to these containerized shipments. This damage occurs when shippers fail to properly protect the items inside a container from other items packaged together. However, these damage rates are significantly less than the overall pilferage and loss rates attributed to military breakbulk cargo moved on the 463L pallets (Gift, 1971:7-8).

Despite the concerns of infrastructure and resource limitations and the advantages associated with containerized movement, certain warnings attributed to containerization must be applied before system-wide implementation of the technology. Mahoney concludes that "(1) there may be certain less obvious advantages to containerized freight and (2) factors going into the decision to use or refrain from using containers in a particular instance are subject to change" (Mahoney, 1985:4). Recognizing the influence of these additional factors can frame the discussion of commercial applications of container technology.

Commercial Applications

Pete Compton, director of commercial marketing for AAR Advanced Structures, declared that "more and more freight operators are recognizing the value in the cargo-handling system. It really does impact their operations and is a value-added element" (Nelms, 1995:88). His conclusion illustrates that essential characteristics favoring commercial adoption of containerization systems to move cargo are gaining prominence with shippers and carriers concerned with the burgeoning transportation industry.

Commercial adoption of container technology recognized the economic benefit of these devices. Intermodal containers can speed the transfers and minimize the delays of port facility handling, while restoring accountability efficiencies designed to track and secure cargo with its packaging equipment. Containers are more compatible with existing automated material handling equipment in large commercial cargo handling facilities than breakbulk movement equipment like pallets. The modular nature of containerized shipments means each movement can adapt to rapidly shifting demand for

the particular cargo load. This modular property of containers provides unitized cargo capability. Unitized cargo is an aggregation of separate items or pieces of cargo into a single unit by means of a standardized unit load device. Additionally, containers provide for an efficient transfer of cargo from one transportation mode to another or among shipments without interrupting the distribution system handling the cargo. In the military, as well as with their civilian counterparts, containers sized to fit a particular airframe can be exactly substituted when priorities change for particular missions (Transportation Research Board, 1992:13-5). The economic benefits of containers encourage continued use by commercial transportation firms.

Limitations to intermodal systems using the devices, however, require careful cost analysis. For air cargo shipments, the weight of some containers (specifically, the older 8x8x20-foot container), plus the cargo shipped within them, could result in rates that exceed those normally allowed for a particularly sized movement. The higher tare weight of these containers, compared to the generally lighter pallets, means that more of the required shipping costs are allocated to its typically less dense cargo. Containers are generally expensive to purchase and possess height limitations different than those of other transportation modes. Containers are specially designed for specific airframes, limiting inter-aircraft transfers. Lastly, if operated as an intermodal alternative to breakbulk load devices and when compared to the number of aircraft available, containers would be required in far larger numbers (Mahoney, 1985:50-1).

The careful analysis of economic factors concerning cost, intermodal transfer, and unit load flexibility is required to provide the commercial transportation industry with accurate and applicable data designed to benefit the decision making process for

container utilization. In the military, this economic analysis has been less carefully applied. The existing environment of regulatory initiatives leaves individual units free to apply the system only as they are able to within the scope of resource availability.

Regulatory Guidance

Regulatory guidance concerning the adoption of air cargo containerization practices in the military remains a scattershot attempt at logistics and mobility effectiveness. Military initiatives to overhaul regulations and issue framing guidelines left containerization adoption alternatives open to unit interpretation during the early 1990s. Applicable regulations and civilian policy guidance are described in a timeline dating to 1992. This period is significant, given its close proximity to the aftermath of OPERATION DESERT SHIELD/DESERT STORM in 1990 and 1991 and the subsequent military drawdown.

The General Accounting Office issued a report detailing the urgent need to "streamline" the United States Transportation Command (USTRANSCOM). Included in the report is testimony to the House Appropriations Committee (Defense) by General Ronald Fogleman, Commander-in-Chief, USTRANSCOM (CINCUSTRANSCOM), in 1992. General Fogleman declared that the goal of mobility forces was to move cargo the same way as it was moved in times of war. This initiative would simplify the cargo processing and shipment systems and would satisfy contingency response and accountability requirements in periods of increased operational levels and in the event of a formal declaration of war. The testimony by General Fogleman followed congressional evaluation of the Defense Transportation System (DTS) that concluded USTRANSCOM

is "replete with redundant organizations and inefficient and costly procedures" (General Accounting Office, 1996:4.1). This conclusion followed an earlier recommendation, dating to the OPERATION DESERT SHIELD/DESERT STORM experience, that a single manager for Department of Defense transportation requirements was needed to bridge the inter-service gaps in transportation manning, cargo movement and equipment standardization, and shipment policies.

In response to the congressional testimony provided by CINCUSTRANSCOM, Headquarters United States Air Force issued Air Force Policy Directive 24-2, <u>Preparation and Movement of Air Force Material</u>. The directive provides "policies for packaging, transporting, and delivering Air Force material to comply with public law, stated policy, appropriate instructions, and international agreements." Section 1.2 details the terms for authorized and acceptable Air Force material movements. These standards include the proper protection levels of the cargo, on time and undamaged delivery of the material, and the inclusion of intransit visibility procedures. Additionally, the Policy Directive mandates that cargo movements will be shipped "at the lowest overall cost consistent with the movement requirement" (AFPD 24-2,1993:1.1-1.2). The prescribed level of materials packaging "incorporates the processes and procedures used to protect material from deterioration and damage," including containerization (AFPD 24-2, 1993:A2.8).

Air Force initiatives to address transportation system cost and movement efficiencies were coupled with continued efforts by the Department of Defense to streamline cargo movement. A 3 May 1995 memorandum from the Deputy Secretary of Defense proposed the Reengineering Transportation Action Plan. In June 1995, representatives from all branches of the military, the Defense Logistics Agency (DLA),

the Defense Finance and Accounting System (DFAS), the Joint Chiefs of Staff (JCS), the Department of Defense Inspector General (DoDIG), the Undersecretary of Defense for Acquisition and Technology, and the USTRANSCOM Comptrollers office established an integrated product team to accomplish four main objectives. These objectives included:

1. Develop a national military transportation vision
2. Reengineer DoD transportation processes
3. Reengineer transportation financial management processes
4. Assess the infrastructure required to support new transportation initiatives.

By October 1995, the product team concluded that the first goal of military transportation efforts should be a "consolidated, global, seamless, and intermodal transportation system that eliminates and decreases infrastructure" contributing to higher costs and less responsiveness to DoD customers (GAO, 1996:4.4).

Air Force Policy Directive 24-2 was implemented by Air Force Instruction (AFI) 24-201, Cargo Movement, on 1 August 1996. The instruction "assigns responsibilities and provides guidance and procedure on the planning, documentation, funding, and other actions associated with the movement of Air Force cargo in both peace and wartime" (AFI 24-201, 1996:4.1). As AFPD 24-2 provides for the movement of material at the lowest cost consistent with the requirement for shipment, AFI 24-201 declares:

> Transportation provides an immediate and effective way to cut the logistics pipeline. Maximum pipeline performance is the primary consideration in Lean Logistics, not transportation cost. While the cost of some individual shipments may be higher than previous shipping modes, customer service is improved while the overall cost of the logistics system is actually reduced. (AFI 24-201, 1996:13.2)

Instructions to military units concerning the adoption of efficient transportation systems are not exclusively the domain of HQ USAF directives.

In 1997 and 1998, the Joint Chiefs of Staff (JCS) and the United States Air Force's Air Mobility Command (AMC) published information concerning the adoption of intermodal innovations to move military material. JCS Publication 4-01.7, Joint Tactics, Techniques, and Procedures for Use of Intermodal Containers in Joint Operations, challenged military units to "foster new mobility concepts and aggressively promote and exploit new technological opportunities" (Joint Chiefs of Staff, 1997:1-30). The Air Mobility Master Plan (AMMP), published annually by AMC, outlines the mobility processes employed by the USAF to meet the requirements of implementing the Global Reach Laydown (GRL) plan. The AMMP includes detailed provisions for the modular, interoperable, and efficient transportation of military equipment and material to meet the rapid mobility requirements of the U.S. military (Air Mobility Command, 1998:4-22).

Military directives require that material move at the lowest possible cost commiserate with the shipment requirement while providing appropriate levels of cargo protection and tracking capabilities. These guidelines are established to ensure that the national military objectives of strategic mobility are met with innovative and effective application of new and existing transportation technologies.

Present Framework

The Defense Transportation System (DTS) provides the required transportation components for movement of military personnel and equipment to support national

military objectives. This capability relies on the implementation of effective and efficient intermodal cargo containerization processes to maximize system advantages and provides awareness and direction for the avoidance of containerized shipment challenges.

Strategic mobility is defined as the "total capability of a nation to project a military force outside its own boundaries to protect or secure some national interest" (Baskett, 1991:2). The strategic mobility of a nation can be measured by two factors: readiness and sustainability (Baskett, 1991:27). The credible application of military force to accomplish either of these mobility objectives relies on the employment and design of equipment to meet established national security goals. Accordingly, Roger Baskett declares that the strategic airlift capability of the United States is its key to strategic mobility that supports national military objectives. Air refueling capacity, aircraft and aircrew availability, and decreased turnaround times for critical missions enhance the rapid deployment capability of a downsized military. The infrastructure of the Air Force transportation system, however, must be included as a separate component of this strategic lift requirement analysis before its success can be measured (Baskett, 1991:29).

The notion of separating strategic mobility requirements into distinct components is not limited to the infrastructure provided to aircraft and aircrews moving required mobility material. According to the Congressional Budget Office (CBO), these additional components are required to complete DoD mobility requirements for the DTS:

- Heavy-duty trucks and forward-located trains
- Skilled personnel to manage port and storage facilities
- Computer systems for information and communication
- Arrays of special equipment (loaders, cranes, forklifts, and containers)

The CBO concluded that "investments in these components is as important as decisions to increase the [strategic] lift capability by increasing the number of airframes, ships, or stores" (CBO, 1997:xii).

In addition to employing appropriate transportation components to support strategic mobility objectives, the design of critical equipment remains an important aspect of readiness. Mobility equipment must be designed from its proposal stage to fit on the aircraft that will move it to a fight. These design considerations transcend applicable transportability issues and include the delivery of material at the destination. Designs for enhancing the readiness of mobility forces must include a measure of how quickly the equipment can be employed once the aircraft has delivered the shipment to its destination (Baskett, 1991:27).

The applications of container technology to the challenges of strategic mobility are established in its effective movement and inherent modal advantages. The unitization of cargo, so that large numbers of small packages can be handled as a single large unit, stands as an economical reason to support containerization innovations. This consolidation effect enables adequate interoperability with existing material handling equipment. Additionally, without adequate containerization of shipment cargo, each movement must be packaged for the extreme conditions of the DTS. These conditions could include an increased number of handling opportunities and exposure to unfavorable weather elements (Gift, 1971:16-21). Decreasing the number of cargo handling opportunities reduces the intransit time and results in faster loading, unloading, and cargo discharge operations (Sveen, 1972:19).

The implementation of air cargo containerization on strategic mobility requirements, however, faces several process obstacles. The integrated logistics system required to maintain, deploy, and track containerized shipments requires extensive fixed port locations. The port facilities are required due to the dependency of container operations on support from other transportation system components (Sveen, 1972:12). These locations receive, sort, load, and discharge the containers earmarked for strategic mobility purposes. This limitation illustrates the traditional bottlenecks of transportation operations spanning commercial and military shipping processes. Port congestion at either the APOE or APOD, coupled with the size and number of warehouses available and the supply of labor at either end of the movement, will limit the effectiveness of container shipments touting faster transit time and comprehensive tracking capability (Bing, 1971:27-8). Lieutenant Commander Gerald Sveen concluded that air cargo containerization problems include the "control, documentation, scheduling, and procurement of large storage areas" (Sveen, 1972:24).

Current applications of the air cargo containerization technology, however, seemingly minimized these traditional limitations. In the Military Traffic Management Command (MTMC), the Transportation Engineering Agency (TEA) recognized a growing trends towards containerization and developed standards for United States Army (USA) material destined for movement aboard USTRANSCOM aircraft. Individual unit containers were required to meet established international standards for size, strength, and lift points. Additionally, the containers must integrate with existing material handling systems, to include helicopter lifts, forklifts, and cranes (Slinger, 1985:41-2). More recently, USTRANSCOM officials declared that "container movements readily

lend themselves to the quick transfer between different transportation modes." USTRANSCOM concluded that containers are simply more practicable to use for certain types of ammunition and supplies because they can be moved so rapidly (Brennan, 1993:17). These sentiments merely echo the conclusions of Lt Comdr. Sveen over twenty-five years ago when he concluded that "if the military logistics system is to function effectively, it must take advantage of containerization or suffer double handling and inefficiency" (Sveen, 1972:45).

By examining the history of cargo containerization efforts in the civilian and military sectors and summarizing the applicable commercial practices, regulatory framework, previous research, and current position of military adoption of cargo containerization efforts, the advantages and disadvantages of intermodal consolidation innovations can be established. Discovery of quantifiable costs associated with procuring and maintaining cargo containers for the Air Force, and exploration of the factors influencing the use of these devices by units in the Air Force will be accomplished next.

III. METHODOLOGY

Introduction

The research conducted for this thesis consisted of two approaches to evaluate the adoption of air cargo containerization systems for the United States Air Force. First, inputs from field users familiar with the operation of container and pallet systems were gathered to discover common experiences, challenges, and opportunities. This information was used to identify the non-cost factors of both cargo handling systems. Second, the cost of an air cargo containerization system, specifically the ISU bins provided by AAR Cadillac Manufacturing, and costs incurred with the current 463L pallet movement system were collected. An Air Cargo Containerization and Palletization Life Cycle Cost model was then developed to compare the costs of both systems.

Research Questions

This research addressed the following questions:

- Are there common factors (among current users) that recommend adoption of air cargo containerization methods for Air Force transportation requirements?
- What limitations exist in the adoption of air cargo containerization systems for the USAF?
- Do the conclusions of previous research apply to USAF adoption of an air cargo containerization system?
- What are the costs associated with implementing air cargo containerization systems from AAR Cadillac Manufacturing?

- Which cargo movement system (pallets or containerization) costs less in terms of maintenance, procurement, and life expectancy?

Scope

This research examined ISU bins and pallets constructed by AAR Cadillac Manufacturing. These bins are engineered for specific airframes and include accessories for ventilation, climate control, airdrop, and helicopter operations. Significantly, these bins are designed for use with existing 463L system rollers, rails, and tiedowns. No additional material handling equipment will be required to handle the containers as current k-loaders (including the new 60k machines) and forklifts are completely compatible with the bins. The pallets were standard 463L-compatible units.

The relatively small number of field users with the ISU bins from Cadillac AAR Manufacturing limited the available number of respondents. The four respondents included:

- Dick Langstraat, consultant for Mobility Systems, Cadillac AAR Manufacturing. Retired as a United States Army Warrant officer with experience in airdrop systems, he has worked at Cadillac AAR Manufacturing for 15 years.
- CW2 David Peterson, Task Force 160, Fort Campbell KY. He has been an accountable officer for nearly five years.
- MSgt Jerry Baird, 142nd Logistics Support Flight, Portland (ANG) AFB OR. He has been a logistics planner for 10 years.
- SMSgt Kerry Coleman, 21st Security Forces Squadron, Peterson Field CO. He is currently the Operations Superintendent and has worked in Security Forces for 17 years.

Non-cost Factors

Factors relevant to container technology adoption have been discussed extensively in recent academic literature. In his 1996 thesis, Mancy proposed factors for

consideration prior to implementation of an air cargo containerization system. Mancy listed each factor as a benefit to adoption, an acquisition feasibility objective, or a constraint on operations. Benefits included: reduced damage, pilferage, documentation, and handling; space efficiency; cargo tracking; specialized cargo; pre-clearing and –weighing; faster cargo movement; and better customer service. Acquisition feasibility objectives are mandated by the Department of Defense and determine the suitability of a particular purchase. Mancy included these objectives: transportability, interoperability, reliability, safety, training, and logistics. Air cargo containerization constraints, again according to Mancy, consisted of: container tare weight, interoperability, backhaul, expense, damage, and cargo fit (Mancy, 1996:18-36).

Based on Mancy's framework, twelve factors were selected for further examination. The factors are shown in Table 1.

Table 1. Container Usage Evaluation Factors

Container Content Damage	Theft of Contents	Operator Safety
Cargo Tracking and Documentation	Speed of Cargo Movement	Pre-clearance and –weighing
Container Handling	Customer Service	Interoperability
Space Usage	System Reliability	Storage

The factors listed in Table 1 were evaluated for the air cargo containerization system and the current 463L pallet system to determine whether differences existed between the two systems. Respondents were also asked whether they would recommend adoption of air cargo containerization systems to other units based on their experiences using the technology. Factors not included in the telephone survey instrument, but

discussed in this study include backhaul, cargo fit, and transportability. All factors will be examined in Chapter IV, Data Analysis.

A telephone survey modeled after Dillman's Total Design Method used these factors as the basis for comparing the two cargo handling systems. Attitudinal and belief questions were directed to responsible individuals and units already familiar with the container technology. These questions were designed to provide the respondents the opportunity to frame flexible responses, stimulate further discussion, and defend strong opinions (Dillman, 1978:87). The respondents were notified using a vendor-provided customer list of current AAR Cadillac Manufacturing ISU bin customers. This panel consensus method established common background terminology, assumed user familiarity with, not avocation of, particular shipment methods, and represented a limited range of interested users, managers, and service providers. Consensus by the respondents concerning these subjective factors helped illustrate the total effect of system adoption. The complete telephone survey instrument is included as an appendix to this thesis.

Cost Factors

Costs associated with the procurement, maintenance, life expectancy and damage rates were collected from vendor provided data sources and the telephone survey instrument. The survey instrument and the vendor list were necessitated due to the lack of available system-wide cost figures concerning these containers. The costs of the proposed container life-cycle model were matched to corresponding figures associated with using the current 463L pallet system. The cost analysis section includes additional, non-quantified sources of expense for each cargo handling system.

IV. DATA ANALYSIS

Introduction

The research was conducted using bibliographic sources, interviews with responsible users (panel consensus), and life expectancy, procurement and maintenance cost figures. Results were tabulated as a Life-cycle Cost model for the cost figures and exploration variables for the non-cost containerization factors.

Data Analysis

Each of the focus areas for this research required different analytical techniques to quantify and qualify the study results. The cost figures were calculated using procurement lists and interviews responses from responsible units. The non-cost factors were explored by consensus following telephone interviews of the respondents.

Cost Data

The life cycle cost model for air cargo containerization and palletization was based on the one-time repair model for 463L pallets developed by Schroeder, Martinez, and Galloway in 1997. The model used historical data to determine the one-time repair life cycle cost for 463L pallets. The variables considered included the estimated average cost of the repair, the estimated cost of shipping, the number of pallets repaired, and the purchase cost of the pallet. These costs were totaled to determine the Life-cycle Cost of Repaired Pallet (Schroeder, Martinez, and Galloway, 1997:11).

The Life-cycle Cost of Repaired Pallet was adapted to include different costs for the Air Cargo Containerization and Palletization Life Cycle Cost model. The air cargo containerization and palletization equation for calculating life-cycle costs consisted of the current cost of purchasing the equipment and the anticipated average preventive maintenance cost. These costs were selected due to the 30-year life expectancy of Cadillac AAR Manufacturing ISU containers (Langstraat, 1998). Preventive maintenance, proper usage, and safe operation of material handling equipment should contribute to the longevity of these assets. Since AAR Cadillac Manufacturing dispatches maintenance teams to accomplish on-site repair for the containers, shipping costs were not included in the calculations (Langstraat, 1998).

The costs for various configurations of AAR Cadillac Manufacturing air cargo containers are provided in the following table (Table 2).

Table 2. Costs for AAR Cadillac Manufacturing Air Cargo Containers and Pallets

Container Number[1]	Type and Nomenclature[2]	Purchase Cost[3]	Life Expectancy (years)[4]	Maintenance Cost[5,6]	Life-Cycle Cost[7]
ISU-70KC	Four Door Contoured	$8,049.43	30	$50	$8,099.43
ISU-90I	Four Door w/aisle	$7,514.11	30	$50	$7,564.11
ISU-90KCI	Animal Transport	$12,691.22	30	$50	$12,741.22
HCU-6/E	Air Cargo Pallet (463L)	$1,163.56		$500	$1,663.56

1. Baird and Coleman, 1998; Schroeder, Martinez, and Galloway, 1997; Mobility Systems, 1997a:3,9, and 47; and Mobility Systems, 1997b:1
2. Mobility Systems, 1997a:3,9, and 47; and Mobility Systems, 1997b:1
3. Baird and Coleman, 1998 and Mobility Systems, 1997d:1-3
4. Langstraat, 1998.
5. Peterson, 1998; Schroeder, Martinez, and Galloway, 1997
6. One time annual cost (preventive maintenance on containers, repair for pallets)
7. One-time cost

As indicated by the table, the life cycle costs for procuring and maintaining pallets and air cargo containers are vastly different. Containers are more expensive to obtain and repair, based on a one-time cost of maintenance performed. Additionally, the cost of the cargo handling equipment differs based on the capability of each asset. These capabilities will be discussed in the next section.

Although the Air Cargo Containerization and Palletization Life-cycle Cost model includes purchase and maintenance costs, it does not account for additional sources of costs associated with the implementation of either system. For example, the costs associated with the build-up or breakdown of shipments using the particular equipment, the cost associated with backhaul of either cargo handling item, and the storage expense of surplus equipment. The current 463L pallet cargo handling system requires additional aerial port personnel to be assigned to pallet and net sections within the air freight and air passenger sections. These members are charged with building, securing, and preparing air cargo shipments for movement on 463L pallets controlled mainly by the aerial port. Implementation of an air cargo containerization system, however, could reduce the total number of members required to accomplish this cargo preparation function.

In addition to the costs of buildup and breakdown of containerized and palletized shipments, backhaul costs of empty containers and pallets may also need to be addressed. The existence of alternative methods to move the equipment from the theater of operations to a point of origin limits the accurate capture of cost data for this factor. Sealift is generally cheaper, but slower than air travel. Its large capacity for material, however, enables large numbers of used containers to return from the deployed locations without burdening the limited space available on transport airframes. In addition, some

units already using the air cargo containers have incorporated alternative uses for the containers into their field operations. These innovations diminish the requirement for immediate backhaul of the assets (reducing the strain on the limited number of airframes available during the initial phases of most deployments). Some units equip the containers with available canine kennel or All-terrain Vehicle storage accessories (Coleman, 1998). Other uses include weapons shelters, offices, and warehouse functions (Mobility Systems, 1997c:1-4). Each survey respondent claimed that the unit deploys with their own containers, reducing wait times and limiting potential transfer and accountability mistakes. Lastly, some of the backhaul costs incurred by shipping the used containers can be classified as opportune. Some available airframes may return empty because of the absence of available or eligible cargo. The addition of a few air cargo containers may take advantage of this free DTS efficiency.

Costs are a significant portion of the acquisition and development processes required within the Department of Defense for procurement of new military-use end items. The costs associated with the procurement and maintenance of these ISU containers represent the core problem of economic analysis. This problem concerns the reconciliation of a consumer's search for utility with rational economic constraints (Birchenhall and Grout, 1984:x). Applied to military users of the strategic mobility system, the efficient movement of unit cargo to and from deployed locations (consumer utility) is limited by the finite Department of Defense budget (rational economic constraint). Fortunately, factors concerning the utilization of air cargo containerization rely not only on the results of life-cycle cost analysis, but also on the evaluation of potential benefits from non-cost criteria.

Non-cost Factors

"The key to an efficient logistical system is the efficient movement of material to strategic locations" (Bennett and Abel, 1972:23). Non-cost factors concerning the utilization of air cargo containerization in the USAF, then, should allow for the "efficient" shipment of needed material throughout the Defense Transportation System (DTS). The telephone survey conducted during the course of this research explored the attitudes and beliefs of users familiar with present air cargo containerization systems as introduced in Chapter III, Scope. The data collected from this survey is discussed using the factor framework proposed by Mancy in 1996 (see Table 1).

Container Content Damage. All respondents indicated that the damage to contents of air cargo containers was less than that of other types of cargo handling equipment. The inclusion of container-specific accessories like weapons racks, reinforced floors, and shaped drawers dictated the packing of all required equipment within the container and assisted preparation of the shipment.

Theft of Contents. Three respondents indicated that theft of the container contents was less than that of other types of cargo handling equipment. However, one respondent indicated that theft was not applicable since the unit (Task Force 160) packed, secured, and shipped its equipment only as a unitized whole. Members of the task force accompanied the container through each step of the transportation system, leaving little possibility for potential pilferage opportunities by personnel outside the unit.

Container Handling. Each respondent rated this question differently. Concerns about the familiarity with the containers of port operations personnel indicated a higher

level of container handling for one respondent. Another participant indicated handling of the containers increased as his unit assumed responsibility for delivering the prepared container to the port for shipment. The other respondents indicated less handling or the same amount of handling was required, depending on whether pallets or containers manufactured by a competitor were evaluated against the AAR Cadillac Manufacturing equipment.

Space Usage. All respondents indicated that the use of air cargo containers made more efficient use of the available cargo space within the containers. The 90" height capability of the ISU 90I and ISU–90KCI can be easily maximized with the rigid sides of each container providing needed unit support. The support provided by nets and covers for 90" pallets, however, is less secure and less stable. Additionally, container accessories appeared to be flexible, reliable, and unit-specific.

Cargo Tracking and Documentation. Three survey participants indicated that the cargo documentation and in-transit visibility requirements of air cargo containerization systems were less than the previously used systems. However, respondents also indicated that this accountability factor was assisted by the recent increase in information technology employed to track world-wide systems and the ability of unit members to deploy with the containers carrying unit equipment. The lone dissenting respondent indicated that the tracking and documentation requirements remained the same.

This result seems out of place. Although the regulatory environment has loosened since the early 1990s, the necessity for accurate and complete shipment information has not been lessened. Unless units are adept at essentially prepositioning containers

between deployments, Transportation Control Numbers (TCN) require current dimension data and flight profile placards. This data can change during each contingency. The access of most shippers to the Global Transportation Network (GTN) also adds a new sense of ownership to the shipment process. Documentation, then, seems as important with a containerized load as with one that is palletized.

Pre-clearance and –weighing. All respondents acknowledged that the ability of air cargo containerization systems to clear marshalling, customs, and loading operations was easier than other cargo handling systems. Container benefits to pre-inspection processes included pre-marking all dimensions except for weight, standard operating procedures that weigh only 10 percent of the containers shipped port facilities, and specific unit tasking codes assigned to particular container equipment.

Speed of Cargo Movement. This factor resulted in varied responses from survey participants. Two respondents indicated the speed of the cargo movement was less than that of alternative cargo handling systems. The proper configuration of accessories, the necessity of accurate pre-inspection procedures, and the requirement for airframes compatible with specific containers slowed the transportation process for these units. The other respondents indicated that the speed of cargo movements really depended on the mode of transportation selected for the particular movement. Although the time to build pallets using nets and covers was decreased, the above-mentioned planning and scheduling factors limited some potential transit speed advantages.

Customer Service. Responses were mixed concerning the effect of air cargo containerization on customer service. Task Force 160 experienced little or no disruption to its critical early deployment response capabilities using the ISU bins. Other

participants indicated that the customer service received by their units deploying with the bins was better than identical service using palletization systems.

Interoperability. This factor measured the ability of air cargo container systems to accomplish mobility objectives using a variety of transportation modes. All respondents indicated that the ISU bins purchased by their respective units were contoured specifically for particular aircraft. This specialization decreased airframe flexibility, but maximized potential space efficiency benefits, exceeded all cargo load safety requirements, and still provided for intermodal transfer among 463L-compatible transportation equipment.

System Reliability. All respondents indicated that the air cargo containers were more reliable than the alternative cargo handling systems. The containers appeared to be more resilient to damage, less prone to operator-process errors (improper configuration of pallets), and more likely to protect contents from the effects of weather.

Operator Safety. Three respondents indicated that air cargo containerization systems were safer to operate than alternative cargo handling systems. In six years of roughly continuous contingency use of air cargo containers, Task Force 160 recorded no injuries to personnel due to the containers (Peterson, 1998). The fourth participant indicated that the dangers and risks afforded by containers were the same as the safety factors affected by palletization systems.

Storage. The survey questioned each unit about the suitability of container storage locations when the equipment was not deployed. All respondents indicated that the units stored their own containers on property controlled by the unit , usually outside

of covered shelter. All of these locations were secure and accessible only to select individuals within the unit.

Recommendations. All respondents endorsed adoption of air cargo containerization systems for units using USAF transportation equipment. The data collected focused on two areas concerning utilization of air cargo containerization within the United States Air Force. The cost figures for applicable maintenance and procurement operations were calculated for three ISU bins and the current 463L pallet. A panel of users was questioned using a telephone survey to evaluate the differences between potential air cargo containerization systems and current palletization methods to handle cargo shipments.

V. CONCLUSIONS

Introduction

The adoption of air cargo containerization systems for the United States Air Force depends on user acceptance of performance, cost, and planning tradeoffs prior to implementation of the system. Limitations to the system-wide employment of these containers exist and deserve further research consideration. However, the logistical benefits to military users of these mobility assets and the compatibility of the system with existing material handling and cargo shipping equipment combine to recommend air cargo containerization adoption by the USAF.

Common System Factors

The use of air cargo containerization systems by the surveyed units revealed common benefits recommending the use of this cargo handling system. Reduced contents damage, increased accountability, space usage efficiency, and system reliability factors were consistently cited as advantages to containerization over alternative cargo handling methods. These factors coincide well with previous research indicating containerization benefits over strict breakbulk-type pallet operations or sole mode shipments in the areas of damage, pilferage, and shipment tracking.

The responsiveness of AAR Cadillac Manufacturing and the surveyed units provided additional opportunities to strengthen the implementation efforts of an air cargo containerization system. Aircraft contour requirements are now standard equipment on most ISU bins provided by AAR Cadillac Manufacturing. The units purchasing

containers define specific shipment and deployment needs and equip their containers with all necessary accessories. The units recognized legitimate cross-function capabilities of these containers as they shipped each container via a variety of transportation modes and equipped the shelters with climate control, storage devices, and lighting systems for makeshift shelters.

These common system factors, discovered during telephone surveys conducted on the responsible units, represent the newest in military transportation efficiency technology. The containers used by the participating units appear to be indispensable multi-functional, effective, and cost-conscious mobility tools.

Containerization System Limitations

The adoption of an air cargo containerization system must address certain limitations before system-wide implementation of the innovation is accomplished. Airframe considerations, storage and backhaul concerns, and system familiarity with the technology constrains DTS adoption of these containers.

Airframe compatibility with various container configurations remains a large planning problem. Deploying units, established in the mobility process queue, are subject to the airframe scheduling processes which may match units with aircraft unable to move essential, containerized equipment. Additionally, Mancy describes contour limits imposed by certain airframes that will prevent any adoption of air cargo containerization. These limits include C-141 bulkheads and the aisle way over C-130 wheel wells (Mancy, 1996:30-31). Lastly, the reliance of mobility planners on the capacity of the Civil Reserve Air Fleet (CRAF) must be considered before system

implementation. Presently, 40% of the material requiring movement by airlift during a contingency will be transported by CRAF program participants (Cunningham, 1998).

The containers presented in Table 2 address some of these system concerns. The ISU-70KC is contoured specifically for the Boeing KC-135 Stratotanker. The ISU-90-I incorporates the required emergency access aisleway for operations aboard the Lockheed C-130 Hercules. Each of the containers are compatible with both commercial airframes and Air Mobility Command (AMC) aircraft due to their standard 108"x88" base (Mobility Systems, 1997a:3,9, and 47). CRAF participants comply with the military 463L system standard as a condition of membership in the contingency program.

Storage and backhaul of large numbers of these containers can choke already stressed transportation facilities and scarce shipment resources. The space required for containerization systems is much larger than the current pallet-based method. Currently, however, transportation ports provide centralized storage for masses of unused pallets in preparation for contingency requirements. Air cargo containerization systems would benefit from unit ownership of these assets, with the responsible unit arranging and controlling the storage facility. Potential backhaul solutions for moving used or spent containers from destination locations back to their origin include: prioritizing the transit time requirements; increasing the ability of units to travel with the equipment; and anticipating the remaining time for re-deployment of the unit cargo. These planning efforts may recommend a shipment alternatives other than expensive, and scarce, airlift resources or suggest opportune airlift utilization as it becomes available. Bennett and Abel described these scenarios when cautioning transportation practitioners to be aware

of the “disproportionate amount of emphasis on the cost of premium transportation services” (Bennett and Abel, 1972:71).

System familiarity factors include training, safety, and regulatory guidance. Equipment operators must recognize and apply material handling knowledge to safely and efficiently move the containers throughout the Defense Transportation System. Proper use of material handling equipment with the integrated lift points and forklift tubes, unit compliance with loading and handling instructions, and accurate marking of dimensions and weight could lengthen the life of each mobility asset and reduce potential damage to the containers.

Containerization Costs

The initial costs for procurement of air cargo containerization assets remain higher than costs associated with the current pallet-based cargo handling system. Although these initial procurement costs are high, the benefits gained from responsive maintenance, longer life expectancy cycles, and the non-cost factor tradeoffs discussed earlier, may outweigh these costs.

The life expectancy of ISU bins provided by AAR Cadillac Manufacturing, provided regular maintenance is accomplished, exceeds 30 years (Langstraat, 1998). Costs associated with continual use cycles and its effect on the above categories could illustrate marked reductions in costs of containers over the comparable life cycle of palletization systems. New weapons systems, contingency plans, and technology innovations for the containers could justify further examination of the costs.

Research Limitations

The research contained within this report is limited by its reliance on vendor-provided data sets and the small number of surveyed units. These limitations reduce the overall reliability of the findings as applied to the entire Defense Transportation System.

The vendor-provided data sets included life expectancy figures, procurement costs, and characteristics of container accessories and equipment available for purchase by Department of Defense components. Reliance on this data ignores the potential effect of competition on market prices and equipment innovations and decreases the confidence with which broad system conclusions can be made. Additionally, despite survey respondent concurrence with the provided cost data for procurement and maintenance calculations, the small sample size of affected users limits the validity of conclusions reached from the inclusion of this data.

The small sample size of responsible units familiar with air cargo containerization technology poses additional research limitations. The significance of factor concurrence among the respondent panel is limited by the magnitude of non-surveyed units potentially familiar with the operation of air cargo containerization systems. Given that these containers are a relatively new system to the military, the number of qualified units with the containers could be quite small. These units, outside the scope of this research study, could possess alternative views on any of the evaluated container factors. The surveyed sample represents only a portion of the units, by functional specialty, tasked to deploy aboard USAF aircraft. Although the participating units recognized the flexibility and adaptability of air cargo containerization systems, other units may control equipment not suitable for packaging aboard these bins.

The cost analysis of the air cargo containerization system exempted non-quantified backhaul and storage expenses. Any storage costs of the respondents were associated with property already maintained by the unit. The all-weather benefits of the containers and the multi-purpose capability of some of the container accessories, appear to have minimized the costs associated with handling unit-sized quantities of this mobility equipment. Backhaul costs are a concern due to the weight and volume of the empty containers. However, if the containers deploy, and remain with, their owning units until the end of the operation, the containers could then potentially return with the same unit. The flexible application of containers in a variety of unit functions at the deployed location would ensure the continued adequate and appropriate use of these assets.

Proposed Research

Future research should survey a larger sample of responsible units. Possible opportunities exist to question mobility-tasked units using the containers and/or using the pallets. Additionally, the costs associated with the adoption of an air cargo containerization system should become more available as more units purchase the assets. These costs could include preventive maintenance trends and service charge histories. Lastly, the life expectancy figure of the ISU bins manufactured by Cadillac AAR Manufacturing is thirty years. The technical examination of load stress, repeated handling, and damage rates would round the picture of potential containerization benefits. These studies could qualify or alter the findings of factors concerning utilization of air cargo container system in the USAF.

Summary

Air cargo containerization is receiving a significant amount of study attention concerning the cost and trade-off of system utilization factors. The renewed emphasis on transportation effectiveness was predicted by Gift in 1971 when he declared that "the future of safe, fast, and secure strategic mobility operations is not the airlift capability, but better packaging and more efficient cargo handling systems" (Gift, 1971: 33). The Congressional Budget Office concurred twenty-six years later, declaring that "strategic mobility requires a system of equipment, personnel, and logistics know-how for moving military forces over intercontinental distances." The renewed emphasis on military mobilization to meet national security objectives is necessitated by the decreasing number of American troops stationed overseas coupled with the requirement for quick and responsive long distance deployments involving stateside troops (CBO, 1997:xi).

This research indicated that content damage, theft, interoperability, and space usage were unanimously mentioned as factors that rated better than alternative cargo shipment modes, like 463L palletization. The ability of deliberate planning processes to overcome backhaul and storage costs reveals additional factors that should encourage the adoption of USAF unit implementation. Specifically, alternative transportation modes, unit storage responsibilities, and unit accountability for the deployed assets, could provide the necessary solutions to minimize these potential cost challenges. The future familiarity of deploying and support units with the air cargo containerization system will undoubtedly speed the deployment process and encourage even wider use of these mobility container assets.

The efficient and effective application of air cargo containerization in the United States Air Force will provide our fighting units the undamaged equipment they need, when it is needed, and wherever the shipment is demanded.

Appendix: Telephone Survey Instrument

Demographic Data

1. Please spell your full name (Last Name, First Name, and Middle Initial).
2. Please state your current rank.
3. Please state your Job Title.
4. Please estate your organization.
5. Please state your duty location (including zip code).
6. How long have you worked in this unit?
7. What is your career field?
8. How long have you worked in this career field?

Survey Questions

1. Are you familiar with the "Cadillac Bins" provided by AAR Cadillac Manufacturing? ("yes," "no," or "please explain")
2. Which bins, manufactured by AAR Cadillac does your unit currently own or operate? Does your unit own/operate cargo handling equipment other than these bins? (pallets, containers from other manufacturers)
3. How many bins does the unit own/operate?
4. When were these bins purchased?
5. Are these bins primarily a (_______________) asset? Please select from the following response categories:
   - Mobility
   - Peacetime
   - Other (____________) (please specify)
6. Please rate the following factors concerning the use of the containers owned/operated by your unit. The response ratings will be More/Less/Same as previous cargo handling systems. After rating each category, you will permitted to provide additional comments as appropriate.

- Damage to contents
- Theft
- Handling (of the container during loading/unloading/transportation)
- Efficient Use of Space
- Cargo tracking (In-Transit Visibility/Accountability)
- Required Documentation
- Speed of Cargo Movement (from preparation to delivery at destination)
- Customer Service (familiarity of system with operation of the containers)
- Reliability of containers
- Safety of equipment operators
- Ease of loading/unloading
- Ease of inspections

7. Does your unit handle/transport specialized cargo with the owned/operated bins? (HAZMAT, ammunition, weapons)

8. Is your unit able to pre-clear the container prior to shipment. Pre-clear includes weighing, marking, and securing the containers.

9. Has your unit experienced any problems with the containers themselves since they begin using the bins? (Damage, expense, cargo fit) If "Yes," please discuss the nature of the container problem. How were these issues resolved?

10. Has a transportation component (air, sea, or ground modes of transportation) limited or caused problems for the use of these containers by your unit? If "Yes," please discuss the nature of this transportation problem. How were these issues resolved?

11. Where do you store the containerization units? (Outside, in central yard)

12. What mode of transportation (airlift, sealift, ground movement) does your unit typically use to deploy? If "airlift," what type of aircraft is used to move the containers? Are the containers compatible with the aircraft? (Interoperability)

13. Would you recommend the use of these containers to other units in the United States Air Force to meet their mobility needs?

14. Please describe any additional factors concerning the containers that have not been discussed by the previous questions. (Accessories, maintenance costs, unexpected costs, unexpected benefits)

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Vita

Captain Joel W. Gartner was born on 11 November 1970 in Topeka, Kansas. He graduated from Loyola College Preparatory in 1989 and entered undergraduate studies at the United States Air Force Academy in Colorado Springs, Colorado. He graduated with a Bachelor of Science degree in History in 1993. He received his commission upon graduation from the USAF Academy on 2 June 1993.

He was assigned to McGuire AFB where he served as the flight commander for three different flights in two squadrons: combat readiness, vehicle operations, and the Air Terminal Operations Center. In May 1997, he entered the School of Logistics and Acquisition Management, Air Force Institute of Technology. His next assignment will take him to the Passenger Services section at Ramstein AB, Germany.

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13. ABSTRACT (*Maximum 200 Words*)

As the Department of Defense budget continues to decrease, the growing requirement to meet national strategic mobility objectives with limited resources provides a major impetus for cost-effective and credible transportation innovations. The commercial transportation industry has increasingly accepted cargo containerization as a method to take advantage of intermodal shipping efficiency and cost savings. The military implementation of these same shipping initiatives must be flexible, reliable, and compatible with the existing cargo handling systems already designed to deliver fighting forces to conflicts throughout the world.

This thesis examines cost and container utilization factors among units familiar with the ISU bins provided by AAR Cadillac Manufacturing. The objective is to evaluate the costs and factors experienced by the responsible units in the procurement, maintenance, and operation of these air cargo containerization systems. The research results indicate that the Life-cycle cost of containerization may be greater than the comparable costs of the current 463L palletization system. However, these units indicated several potential advantages to air cargo containerization implementation including: reduced contents damage, pilferage, and pre-clearance requirements; improved system reliability and cargo tracking capability; and better system operations.

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